

What is Claimed Is:

1. A method for recording a predefined multiple intensity level image on a substrate, the method comprising the steps of:

converting the predetermined image to multiple intensity level associated images;

converting a light beam to multiple light beam arrays;

modulating each light beam array to provide modulated light beam arrays, in response to a corresponding intensity level associated image to be recorded on the substrate;

directing each modulated light beam array to impinge on the substrate; and

repeating the steps of converting, modulating and directing while moving the substrate until the predefined image is imaged on the substrate.

2. The method of claim 1 further comprising a step of eliminating coherence between different modulated light beam arrays.

3. The method of claim 2 wherein the step of eliminating coherence comprising introducing time shifts between the modulation of different light beam arrays.

4. The method of claim 3 wherein the step of directing comprises compensating for movement of the substrate during these time shifts.

5. The method of claim 3 wherein the compensation comprises a retrograde scan.

6. The method of claim 1 wherein modulated light beam arrays differ by their light frequencies.

7. The method of claim 1 further comprising directing each modulated light beam array via at least one polarizing beam splitter.

8. The method of claim 1 further comprising a step of altering the polarization of at least one modulated light beam array during the step of directing to enable said the at least one modulated light beam array to reach the substrate.

9. The method of claim 1 wherein the intensity levels associated with intensity level associated image differ from each other by a factor of two.
10. The method of claim 1 further comprising altering an intensity of at least one modulated light beam array by polarization.
11. The method of claim 1 wherein the step of converting light beam to multiple light beam arrays comprises collimating a pulse of light beam and splitting the collimated light beam.
12. The method of claim 1 wherein the step of modulating each light beam array comprises directing the light beam array towards a reflective spatial modulator.
13. The method of claim 12 further comprising altering a polarization state of at least the light beam array or the modulated light beam array reflected from the reflective spatial modulator.
14. The method of claim 1, comprising focusing the modulated light beam arrays with an array of lenses after the modulating step.
15. The method of claim 1, comprising moving the substrate substantially linearly in a scanning direction that deviates from an axis of a modulated light beam array such that as the substrate is moved a distance substantially equal to a length of the array in the scanning direction, the modulated light beams trace a substantially continuous path on the substrate surface in a mechanical cross-scan direction.
16. The method of claim 1 wherein the step of moving comprises moving the substrate on a movable stage in a direction slanted relative to the axes of the beam array
17. The method of claim 1 wherein the step of moving comprises moving the substrate such that a different continuous area of the substrate is illuminated during each iteration of the modulating and directing steps.

18. The method of claim 1, wherein each modulated light beam array corresponding to an intermediate intensity level associated pattern on the substrate, and the superposition of the intermediate patterns forms the predefined image on the substrate.

19. The method of claim 1 wherein the step of modulating each light beam array comprising focusing each light beam onto an element of a spatial light modulator.

20. The method of claim 1 further comprising a step of converting a light beam, out of the modulated light beam array, that is oriented in relation to a required optical axis to a light beam that is parallel to the required optical axis and focusing the converted light beam onto the substrate.

21. The method of claim 1 further comprising focusing a light beam array onto modulating elements, collecting a modulated light beam array, converting the modulated light beam array such as to comprise multiple parallel light beams that propagate along an optical path that is normal to focusing optics capable of focusing the modulated light beam array onto the substrate.

22. The method of claim 1 wherein the light beam is generated by a pulsed laser.

23. A method for recording a predefined multiple intensity level image on a substrate, the method comprising the steps of:

converting the predetermined image to multiple intensity level associated images;

converting a light beam to a sequence of time spaced multiple light beam arrays;

for each light beam array of the sequence, modulating the light beam to provide a modulated light beam arrays and directing the modulated light beam array to impinge on the substrate, whereas the modulation is responsive to an input signal corresponding to a corresponding intensity level associated image to be recorded on the substrate;

repeating the steps of converting, modulating and directing while moving the substrate until the predefined image is imaged on the substrate.

24. The method of claim 23 wherein the step of directing comprises compensating for movement of the substrate during the time spaces.
25. The method of claim 24 wherein the compensation comprises a retrograde scan.
26. The method of claim 23 further comprising directing each modulated light beam array via at least one polarizing beam splitter.
27. The method of claim 23 further comprising a step of altering the polarization of at least one modulated light beam array during the step of directing to enable said the at least one modulated intensity associated light beam array to reach the substrate.
28. The method of claim 23 wherein the intensity levels associated with intensity level associated image differ from each other by a factor of two.
29. The method of claim 23 further comprising altering an intensity of at least one modulated light beam array by polarization.
30. The method of claim 23 wherein the step of converting light beam to a sequence of time spaced comprises converting a light pulse to a sequence of light pulses that differ by their intensity level.
31. The method of claim 23 wherein the step of modulating each light beam array comprises directing the light beam array towards a reflective spatial modulator.
32. The method of claim 31 further comprising altering a polarization state of at least the light beam array or the modulated light beam array reflected from the reflective spatial modulator.
33. The method of claim 23 comprising focusing the modulated light beam arrays with an array of lenses after the modulating step.
34. The method of claim 23 comprising moving the substrate substantially linearly in a scanning direction that deviates from an axis of a modulated light beam array such that as the substrate is moved a distance substantially equal to a length of the array in

the scanning direction, the modulated light beams trace a substantially continuous path on the substrate surface in a mechanical cross-scan direction.

34. The method of claim 23 wherein the step of moving comprises moving the substrate on a movable stage in a direction slanted relative to the axes of the beam array

35. The method of claim 23 wherein the step of moving comprises moving the substrate such that a different continuous area of the substrate is illuminated during each iteration of the modulating and directing steps.

36. The method of claim 23 wherein each modulated light array corresponding to an intermediate intensity level associated pattern on the substrate, and the superposition of the intermediate patterns forms the predefined image on the substrate.

37. The method of claim 23 wherein the step of modulating each light beam array comprising focusing each light beam onto an element of a spatial light modulator.

38. The method of claim 23 further comprising focusing a light beam array onto modulating elements, collecting a modulated light beam array, converting the modulated light beam array such as to comprise multiple parallel light beams that propagate along an optical path that is normal to focusing optics capable of focusing the modulated light beam array onto the substrate.

39. The method of claim 1 further comprising a step of converting a light beam, out of the modulated light beam array, that is oriented in relation to a required optical axis to a light beam that is parallel to the required optical axis and focusing the converted light beam onto the substrate.

40. The method of claim 23 wherein the light beam is generated by a pulsed laser.

41. A printer for recording a predefined multiple intensity level image on a substrate, the printer comprising:

a programmable optical radiation source for providing multiple modulated light beam arrays and for directing the modulated light beam arrays to impinge on the

substrate, each modulated light beam array being modulated in response to an input signal corresponding to a corresponding intensity level associated image to be recorded on the substrate; whereas a superposition of the intensity level associated images forms the predefined image on the substrate; and

a movable stage for moving the substrate until the predefined image is imaged on the substrate.

42. The printer of claim 42 wherein the programmable radiation source comprises means for eliminating coherence between different modulated light beam arrays.

43. The printer of claim 43 wherein the means for eliminating coherence effects comprising delay elements for introducing a time shift between different modulated light beam arrays.

44. The printer of claim 43 further capable of compensating for movement of the substrate during these time shifts.

45. The printer of claim 43 further comprising a deflector for directing the modulated light beam arrays in a retrograde scan.

46. The printer of claim 43 wherein the means for eliminating coherence effects are selected from a group consisting of band pass filters and narrowband lasers.

47. The printer of claim 42 wherein the programmable optical radiation source comprises at least one polarizing beam splitter.

48. The printer of claim 42 wherein the programmable optical radiation source includes polarization elements for altering the polarization of at least one modulated light beam array to enable said the at least one modulated intensity associated light beam array to reach the substrate.

49. The printer of claim 42 wherein the intensity levels associated with intensity level associated image differ from each other by a factor of two.

50. The printer of claim 42 wherein the programmable optical radiation source comprises polarizing elements for altering an intensity of at least one modulated light beam array by polarization.

51. The printer of claim 42 wherein the programmable optical radiation source comprises a light source for providing a light beam and light beam converters for converting light beam to multiple light beam arrays.

52. The printer of claim 42 wherein the programmable optical radiation source comprises multiple reflective spatial modulators, each for modulating a single light beam array.

53. The printer of claim 53 further comprising polarizing elements for altering a polarization state of at least the light beam array or the modulated light beam array reflected from the reflective spatial modulator.

54. The printer of claim 42, comprising an array of lenses for focusing the modulated light beam arrays onto corresponding spatial light modulators.

55. The printer of claim 42, wherein the movable stage is capable of moving the substrate substantially linearly in a scanning direction that deviates from an axis of a modulated light beam array such that as the substrate is moved a distance substantially equal to a length of the array in the scanning direction, the modulated light beams trace a substantially continuous path on the substrate surface in a mechanical cross-scan direction.

56. The printer of claim 42, wherein each modulated light array corresponding to an intermediate intensity level associated pattern on the substrate, and the superposition of the intermediate patterns forms the predefined image on the substrate.

57. The printer of claim 42 wherein the movable stage is capable of moving the substrate on a movable stage in a direction slanted relative to the axes of the beam array

58. The printer of claim 42 wherein the stage moves the substrate such that a substantially different continuous area of the substrate is illuminated during each iteration of the modulating and directing steps.

59. The printer of claim 42 wherein the light beam is generated by a pulsed laser. modulated light beam arrays.

60. The printer of claim 42 wherein the programmable optical radiation source comprises:

- an image converter for converting the predetermined image to multiple intensity level associated images;

- a light beam converter, positioned to receive a light beam from a light source, for converting a light beam to a multiple light beam arrays;

- a controller, coupled to the image converter, the light beam converter and to at least one spatial light modulator, for controlling the modulation of the multiple light beam arrays; and

- at least one modulator and directing optics, for providing modulated light beam arrays and for directing the modulated light beam arrays to impinge on the substrate.

61. A printer for recording a predefined multiple intensity level image on a substrate, the printer comprises:

- a programmable optical radiation source for providing sequences of time spaced modulated light beam arrays and for directing the sequences of modulated light beam arrays to impinge on the substrate, whereas each modulated light beam array being modulated in response to an input signal corresponding to a corresponding intensity level associated image to be recorded on the substrate; whereas a superposition of the intensity level associated images forms the predefined image on the substrate; and

- a movable stage for moving the substrate until the predefined image is imaged on the substrate.



62. The printer of claim 62 wherein the programmable optical radiation source comprises:

an image converter for converting the predetermined image to multiple intensity level associated images;

a light beam converter, positioned to receive a light beam from a light source, for converting a light beam to a sequence of time spaced multiple light beam arrays;

a controller, coupled to the image converter, the light beam converter and to at least one spatial light modulator, for controlling the modulation of the multiple light beam arrays; and

at least one modulator and directing optics, for providing modulated light beam arrays and for directing the modulated light beam arrays to impinge on the substrate.

63. The printer of claim 62 further capable of compensating for movement of the substrate during time shifts within a single sequence of time spaced modulated light beam arrays.

64. The printer of claim 62 further comprising a deflector for directing the modulated light beam arrays in a retrograde scan.

65. The printer of claim 62 wherein the programmable optical radiation source comprises at least one polarizing beam splitter.

66. The printer of claim 62 wherein the programmable optical radiation source includes polarization elements for altering the polarization of at least one modulated light beam array to enable said the at least one modulated intensity associated light beam array to reach the substrate.

67. The printer of claim 62 wherein the intensity levels associated with intensity level associated image differ from each other by a factor of two.

68. The printer of claim 62 wherein the programmable optical radiation source comprises polarizing elements for altering an intensity of at least one modulated light beam array by polarization.

69. The printer of claim 62 wherein the programmable optical radiation source comprises a light source for providing a light beam and light beam converters for converting light beam to multiple light beam arrays.

70. The printer of claim 62 wherein the programmable optical radiation source comprises multiple reflective spatial modulators, each for modulating a single light beam array.

71. The printer of claim 71 further comprising polarizing elements for altering a polarization state of at least the light beam array or the modulated light beam array reflected from the reflective spatial modulator.

72. The printer of claim 62, comprising an array of lenses for focusing the modulated light beam arrays onto corresponding spatial light modulators.

73. The printer of claim 62, wherein the movable stage is capable of moving the substrate substantially linearly in a scanning direction that deviates from an axis of a modulated light beam array such that as the substrate is moved a distance substantially equal to a length of the array in the scanning direction, the modulated light beams trace a substantially continuous path on the substrate surface in a mechanical cross-scan direction.

74. The printer of claim 62, wherein each modulated light array corresponding to an intermediate intensity level associated pattern on the substrate, and the superposition of the intermediate patterns forms the predefined image on the substrate.

75. The printer of claim 62 wherein the movable stage is capable of moving the substrate on a movable stage in a direction slanted relative to the axes of the beam array

76. The printer of claim 62 wherein the stage is capable of moving the substrate such that a substantially different continuous area of the substrate is illuminated during each iteration of the modulating and directing steps.

77. The printer of claim 62 wherein the light beam is generated by a pulsed laser.

78. The printer of claim 42 further comprising a microlens array positioned between each modulator and the substrate, for converting a light beam, out of the modulated light beam array, that is oriented in relation to a required optical axis to a light beam that is parallel to the required optical axis and for focusing the converted light beam onto the substrate.

79. The printer of claim 42 further comprising a microlens array positioned between each modulator and the substrate, for focusing a light beam array onto modulating elements, collecting a modulated light beam array, converting the modulated light beam array such as to comprise multiple parallel light beams that propagate along an optical path that is normal to focusing optics capable of focusing the modulated light beam array onto the substrate.

80. The printer of claim 62 further comprising a microlens array positioned between each modulator and the substrate, for converting a light beam, out of the modulated light beam array, that is oriented in relation to a required optical axis to a light beam that is parallel to the required optical axis and for focusing the converted light beam onto the substrate.

81. The printer of claim 62 further comprising a microlens array positioned between each modulator and the substrate, for focusing a light beam array onto modulating elements, collecting a modulated light beam array, converting the modulated light beam array such as to comprise multiple parallel light beams that propagate along an optical path that is normal to focusing optics capable of focusing the modulated light beam array onto the substrate.

82. A method for compensating for angular deviation of modulated light beams, the method comprising the steps of: modulating a light beam array, by a light modulator, to

provide a modulated light beam array, whereas the modulated light beam array comprises at least one angular deviated modulated light beam; converting, by a first focusing optics, each of the at least one angular deviated modulated light beam to a corresponding spatial displaced light beam that propagates in parallel to a required optical axis; and focusing the spatial displaced light beam to a required foci of a second focusing optics.

83. The method of claim 82 whereas the first focusing optics and the second focusing optics are microlens arrays.

84. The method of claim 82 wherein the step of focusing is preceded by passing the spatial displaced light beams through at least one objective lens.

85. A printer for recording a predefined image on a substrate, the printer comprising: a light modulator, for modulating a light beam array to provide a modulated light beam array; whereas the modulated light beam array comprises at least one angular deviated modulated light beam; first focusing optics, positioned such as to convert each of the at least one angular deviated modulated light beam to a corresponding spatial displaced light beam that propagates in parallel to a required optical axis; and second focusing optics, positioned such as to focus the at least one spatial displaced light beam to a required foci of the second focusing optics.

86. The printer of claim 85 whereas the first focusing optics and the second focusing optics are microlens arrays.

87. The printer of claim 85 further comprising at least one objective lens positioned between the first and second focusing optics.